Lysack, W.

1980 Cedar Lake Fish Stock Assessment Program.

MANITOBA
DEPARTMENT OF NATURAL RESOURCES
Fisheries Branch

MS Report No. 80-22, 41p.
1980

89-01578/

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ABSTRACT

A yearly fish stock assessment program was initiated on Cedar Lake in 1979 in response to continuing demands for increases in commercial quotas of Cedar Lake whitefish and walleyes.

Minor changes in the status of walleye and whitefish stocks have occurred since 1979. The instantaneous maturity rates of walleye males and females are 0.457 and 1.043, respectively. Survival rates of experimentally caught walleyes and whitefish have increased slightly. Survival rates of commercially caught walleyes and whitefish have decreased slightly. Most of these changes are attributable to seasonal variation in sampling time between 1979 and 1980.

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INTRODUCTION

This report presents the results of the second annual fish stock assessment program on Cedar Lake. This program was initiated in response to continuing requests for quota increases from Cedar Lake commercial fishermen.

Former fishery and limnological studies of Cedar Lake were described by Lysack (1980a).

The objectives of this study were:

1. to determine changes in cohort and age class strength since 1979.
2. to estimate mortality rates.
3. to describe maturity regimes.
4. to describe growth regimes.
5. to determine the age compositions, mean ages and mortality rates of commercially caught walleyes and whitefish.
6. to determine if any changes have occurred in the status of fish stocks since 1979.
7. to provide a list of fish species presently inhabiting Cedar Lake and to estimate species proportions.

Experimental sampling was restricted to one period in early summer. Commercial samples were collected once in June.

METHODS AND MATERIALS

Experimental Netting

Two fyke nets (0.25 inch bar mesh) were set for 24 hours in late May off the south shore of Cedar Lake (Fig. 1) to determine presence of smaller fish species.

Six gillnet gangs were set in Cedar Lake from May 22 - May 28 (Fig. 1). All gangs except the fourth one were set for 24 hours. The fourth gang was set for 48 hours. Each gang was composed of the following meshes: 5.08 cm(2 in), 7.62 cm (3 in), 8.26 cm (3.25 in), 9.53 cm (3.75 in), 10.80 cm (4.25 in) and 12.70 cm (5 in). Each net in the gang was 45.72 m long and approximately 1.83 m deep.

Numbers of each species caught in each mesh of each gang were recorded.

Walleyes and whitefish caught in the gangs were processed as follows: The fork length of each fish was measured to the nearest 2 mm. Each fish was weighed to the nearest 20 gm. on a Chatillon spring scale (Chatillon, Mississauga, Ontario). Six to ten scales were collected from the left side of each fish. Scales were removed above the lateral line below the anterior edge of the dorsal fin. The sex and state of maturity of each fish was visually determined by examining gonads. Fish were classified as being either immature or mature. The mesh size that caught each fish was recorded.

Commercial Sampling

248 whitefish and 251 walleyes caught in 4.25 inch nets

by commercial fishermen were sampled on June 10 and June 11. These fish were processed as described in the experimental netting section.

Analyses

Scales were analyzed according to Erickson (1979). Routine statistical analyses were performed according to Ricker (1975) and Snedecor and Cochran (1967). Total mortality rates were calculated according to Robson and Chapman (1961).

The mean weighted age of onset of sexual maturity was calculated as follows:

$$Z = \frac{A_1 K_1 + A_2 (K_2 - K_1) + A_3 (K_3 - K_2) + \ldots + A_n (K_n - K_{n-1})}{K_1 + (K_2 - K_1) + (K_3 - K_2) + \ldots + (K_n - K_{n-1})}$$

where A = age (years)

K_n = % mature fish in the n^{th} age class

This is a corrected version of Abrasov's (1967) original formula. Mean age of the commercial catch and t were calculated according to Abrasov (1967). Instantaneous rates of maturity were estimated according to Lysack (1980b).

RESULTS

Experimental Netting

Species proportions

Species proportions (% frequency) were as follows: walleye -12.49, whitefish -11.41, pike -38.71, tullibee -27.64,

white sucker -6.34, longnose sucker -0.33, perch -1.75, sauger -0.38, burbot -0.76, goldeye -0.09 and redhorse sucker -0.09 2113 fish were caught during this study (Appendix A). Species caught in gillnets and fyke nets are listed on Table 1.

Maturity regimes

The mean age of the commercial whitefish catch, 4.72 years, was 0.68 years less than the mean weighted age of whitefish maturity, 5.40 years. The mean age of the commercial walleye catch, 8.26 years, was 0.03 years less than the mean weighted age of walleye maturity, 8.29 years.

Analyses of maturity schedules of walleyes (Table 2) and whitefish, (Table 3) showed significant relationships of maturity frequencies and age for walleyes but not for whitefish (Table 4). walleye males begin maturing before walleye females but mature at a slower rate (Fig. 2). The instantaneous maturity rate of whitefish males was almost equal to that of females (Table 4, Fig. 3). Mature walleyes and whitefish are larger than their immature counterparts at common ages (Appendix B).

Age compositions, catch curves and mortality rates

The walleye age composition ranged from 3 to 15 years with a mode of 8 years and a mean of 7.34 years. The walleye age composition was leptokurtic and contained 3 age classes that each comprised over 20% of the total catch of walleyes (Fig. 4).

Table 1. Fish species caught in fyke nets and gillnets in Cedar Lake, 1980.

Generic and specific name	Common name
Stizostedion vitreum	walleye
Coregonus clupeaformis	whitefish
Esox lucius	pike
Coregonus artedii	tullibee
Catostomus commersoni	white sucker
Catostomus catostomus	longnose sucker
Perca flavescens	perch
Stizostedion canadense	sauger
Lota lota	burbot
Hiodon alosoides	goldeye
Moxostoma sp.	redhorse sucker
Notropis hudsonius	spottail shiner
Notropis atherinoides	emerald shiner
Notropis cornutus	common shiner
Pungitius pungitius	9 - spined stickleback
Noturus gyrinus	tadpole madtom
Etheostoma nigrum	johnny darter
Cottus cognatus	slimy sculpin

Table 2. Maturity schedule of Cedar Lake walleyes, 1980.

Age (years)	No. immature fish			No. mature fish			Frequency of mature fish(%)		
	Males	Females	Total	Males	Females	Total	Males	Females	Total
3	1	1	2	0	0	0	0	0	0
4	1	0	1	0	0	0	0	0	0
5	6	10	16	1	0	1	14.29	0	5.88
6	16	34	50	6	1	7	27.27	2.86	12.28
7	9	37	46	15	4	19	62.50	9.76	29.23
8	6	37	43	32	9	41	84.21	19.57	48.81
9	1	4	5	4	11	15	80.00	73.33	75.00
10				5	5	10	100.00	100	100
11				0	2	2			100
12				1	2	3			100
13				1		1			100
14				0		0			-
15				1		1			100

Table 3. Maturity schedule of Cedar Lake whitefish, 1980.

Age (years)	No. immature fish			No. mature fish			Frequency of mature fish(%)		
	Males	Females	Total	Males	Females	Total	Males	Females	Total
3	3	0	3	0	0	0	0	0	0
4	25	16	41	2	1	3	7.41	5.88	6.82
5	12	15	27	31	23	54	72.09	60.53	66.67
6	3	0	3	23	32	55	88.46	100	94.83
7	1	0	1	13	11	24	92.86	100	96.00
8	1	0	1	12	8	20	92.31	100	95.23
9				3	1	4			100
10				1	1	2			
11				0	0	-			
12				1	0	1			
13					1	1			

Table 4. Linear equations describing proportional rates of maturity with respect to age of Cedar Lake walleyes and whitefish, 1980.

Species	Sex	Linear equation $-\log_e (\frac{k - y}{y} + 1) = -bX_o + bX$	Correlation coefficient	Test F value and d.f.	Significance at P = 0.05	Inflection point (years)	Age at 50% mature (years)
Walleye	Male	Y = -4.023 + 0.457X	0.934	20.57(1,3)	significant	8.80	7.3
	Female	Y = -9.777 + 1.043X	0.994	157.33(1,2)	significant	9.37	8.8
	Combined	Y = -5.963 + 0.647X	0.991	157.63(1,3)	significant	9.21	8.1
Whitefish	Male	Y = -7.217 + 1.240*	0.901	4.30(1,1)	non-significant	5.82	5.3
	Female	Y = -8.174 + 1.240*	0.936	7.07(1,1)	non-significant	5.79	5.3
	Combined	Y = -7.629 + 1.316X*	0.921	5.59(1,1)	non-significant	5.80	5.3

*Ages 7 and 8 deleted from analysis.

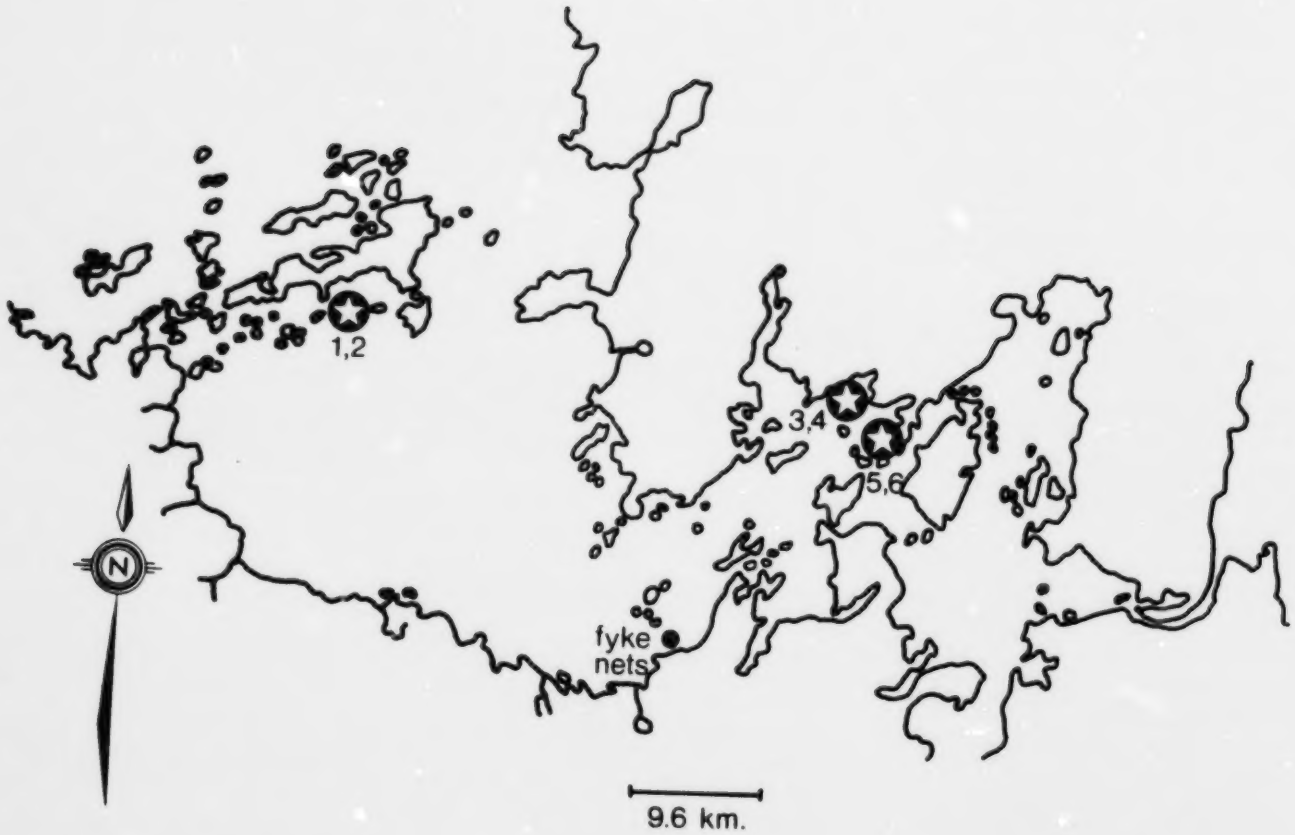

Fig. 1. Map of Cedar Lake showing locations of gillnets and fyke nets.

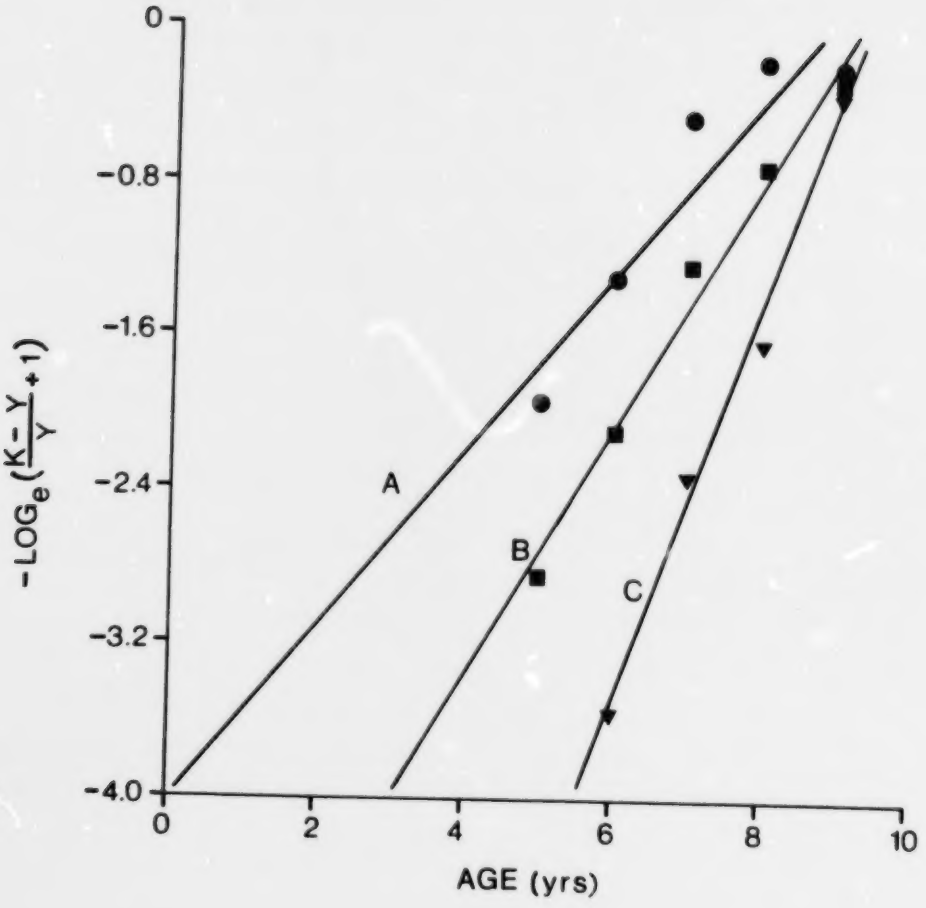

Fig. 2. Male (A), combined (B),and female (C) walleye maturity curves.

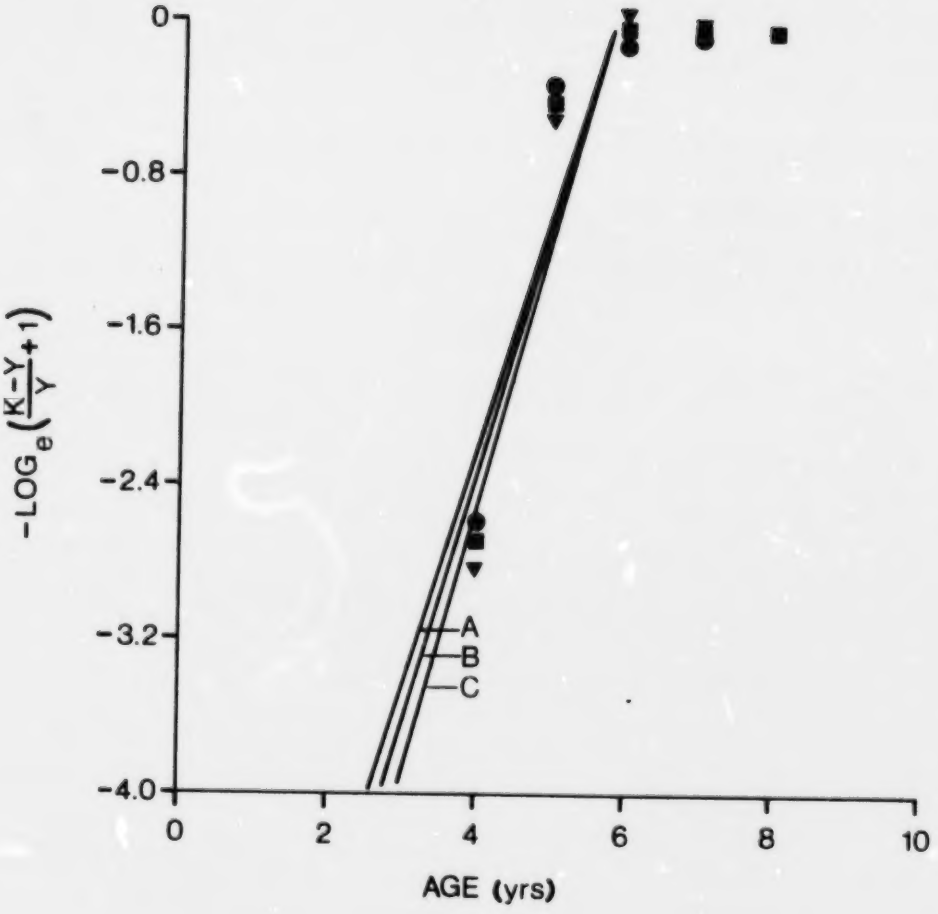

Fig. 3. Male (A), combined (B), and female (C) whitefish maturity curves. Frequencies at ages 6, 7 and 8 were deleted from analysis.

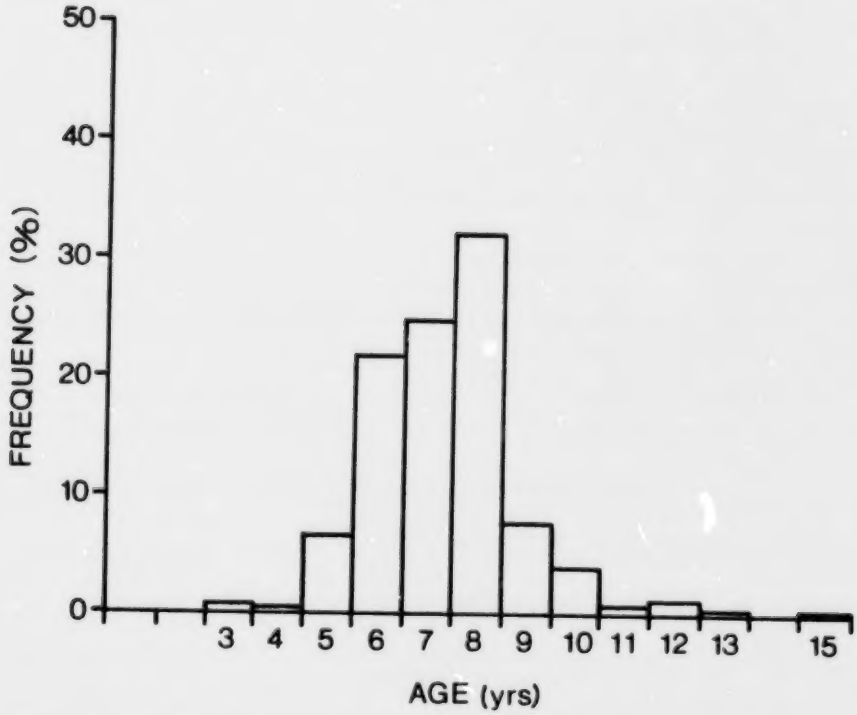

Fig. 4. Experimental walleye catch curve.

The whitefish age composition ranged from 3 to 13 years with a mode of 5 years and a mean of 5.63 years. The whitefish age composition was leptokurtic and contained only 2 age classes that each comprised over 20% of the total catch of whitefish (Fig. 5).

The ascending limb of the walleye catch curve indicates recruitment of relatively strong 6 and 7 year old age classes. The descending limb is concave (Fig. 6). The whitefish catch curve indicates that a relatively strong 8 year old age class is passing out of the fishery (Fig. 7). Regression analyses of the descending limb of the catch curves produced estimates of instantaneous total mortality rates that were not significantly different from Robson-Chapman estimates (Table 5).

Growth regimes

Age-specific mean lengths and mean weights of walleyes (Table 6) and whitefish (Table 7) were used to derive length-weight relationships (Table 8). Both walleyes and whitefish exhibit positive allometric growth.

Walford plots for walleyes (Fig. 8) and whitefish (Fig. 9) showed significant relationships of L_{t+1} and L_t (Table 9). To determine growth rates, age-specific mean lengths were transformed using exponential and von Bertalanffy transformations (Table 10). Correlation coefficients of regressions of $\log_e (L_\infty - 1_t)$ on t (Figs. 10, 11) were considered to represent the von Bertalanffy growth curve since these regressions provide estimates of parameters comprising the von Bertalanffy equation.

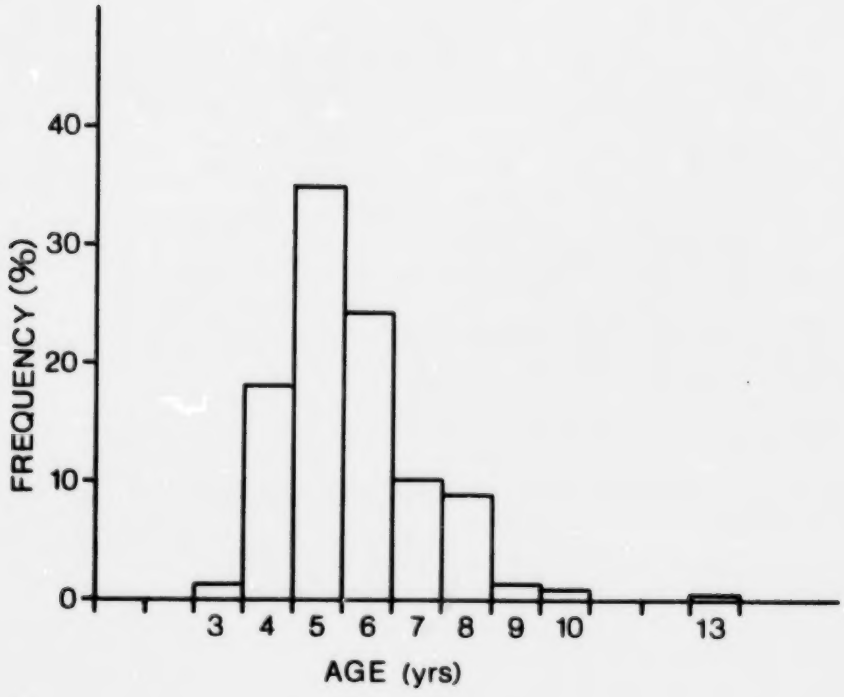

Fig. 5. Experimental whitefish catch curve.

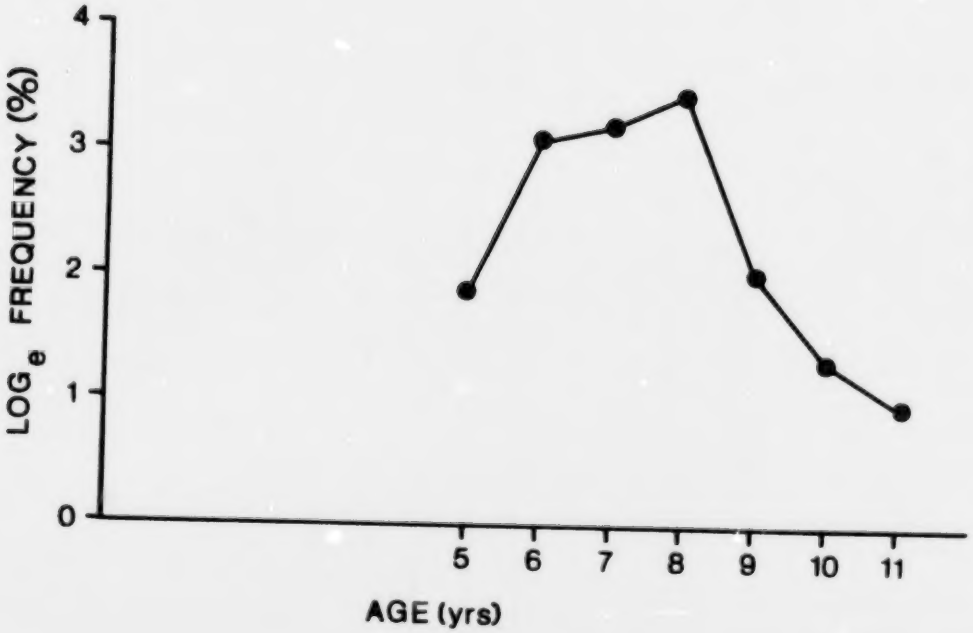

Fig. 6. Experimental walleye catch curve.

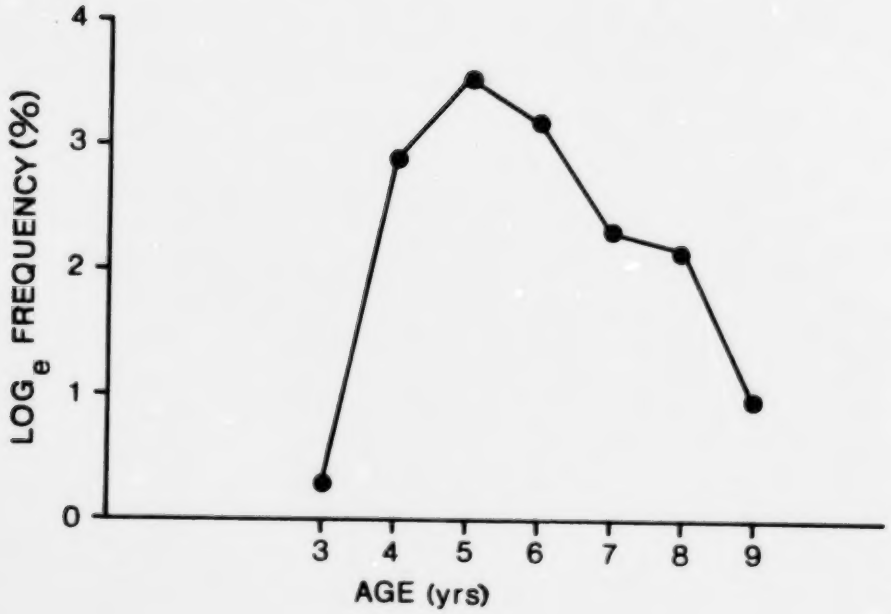

Fig. 7. Experimental whitefish catch curve.

Table 5. Whitefish and walleye survival rates estimated by regression and the Robson-Chapman method.

Species	Robson-Chapman			Regression		
	Z	A	S ± S.E.	Z	A	S
walleye	0.81	0.5551	0.003 < 0.444 < 0.885	0.525	0.4114	0.5886
whitefish	0.79	0.5462	0.224 < 0.452 < 0.681	0.679	0.4934	0.5066

Table 6. Age-specific mean fork lengths and mean weights of walleyes.

Age (years)	No. fish	Mean length (mm)	Mean weight (gm)	Standard error	
				length	weight
3	2	230.00	140.00	0	0
4	1	250.00	180.00	-	-
5	17	337.82	452.35	6.04	24.43
6	57	363.79	571.05	3.81	17.96
7	65	397.28	735.23	4.37	24.68
8	84	410.68	816.43	3.44	20.58
9	20	450.25	1056.50	9.43	64.99
10	10	487.60	1324.00	10.73	92.41
11	2	534.00	1770.00	50.00	570.00
12	3	502.67	1596.67	54.76	521.23
13	1	460.00	1070.00	-	-
15	1	532.00	1820.00	-	-

Table 7. Age-specific mean fork lengths and mean weights of whitefish.

Age (years)	No. fish	Mean length (mm)	Mean weight (gm)	Standard error	
				length	weight
3	3	308.67	526.67	25.46	124.68
4	41	352.24	817.80	3.44	27.81
5	79	402.49	1229.24	3.88	38.25
6	55	451.16	1732.55	3.19	41.16
7	23	467.96	1988.26	5.38	62.73
8	20	496.10	2409.00	5.34	93.19
9	3	505.67	2516.67	2.19	256.41
10	2	569.00	3530.00	7.00	10.00
13	1	609.00	4380.00	-	-

Table 8. Length-weight relationships of Cedar Lake walleyes and whitefish.

Species	Length-weight equation	Correlation coefficient	Test F value, d.f. and significance at P = 0.05
walleye	$\log_e$ weight = -11.524 + 3.028 $\log_e$ length	0.999	7164.20(1,10) significant
whitefish	$\log_e$ weight = -11.539 + 3.110 $\log_e$ length	1.000	12461.48(1, 7) significant

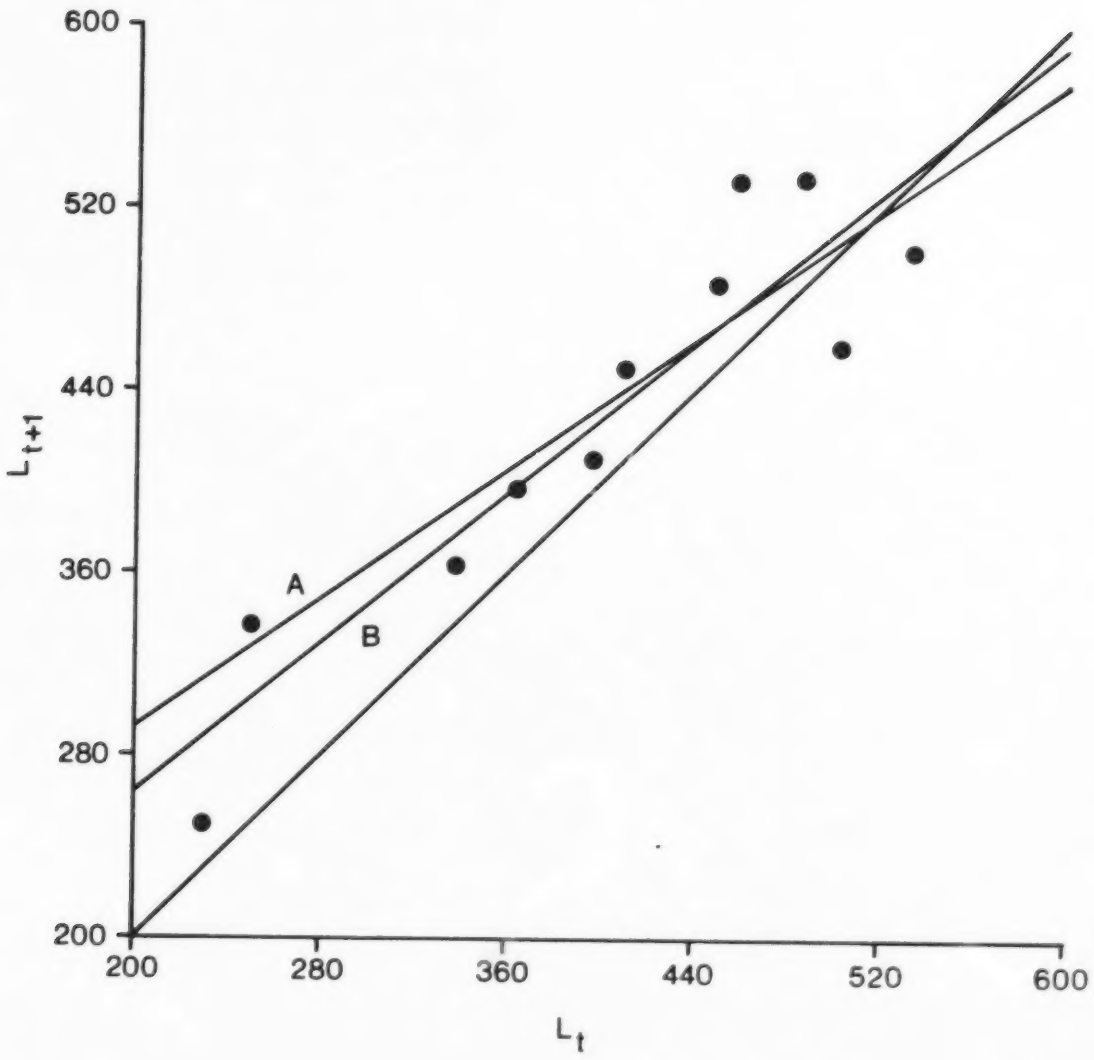

Fig. 8. Walford plots of walleye lengths. A - L_∞ = 515 mm with L_1 deleted. B - L_∞ = 550 mm with all points included in regression.

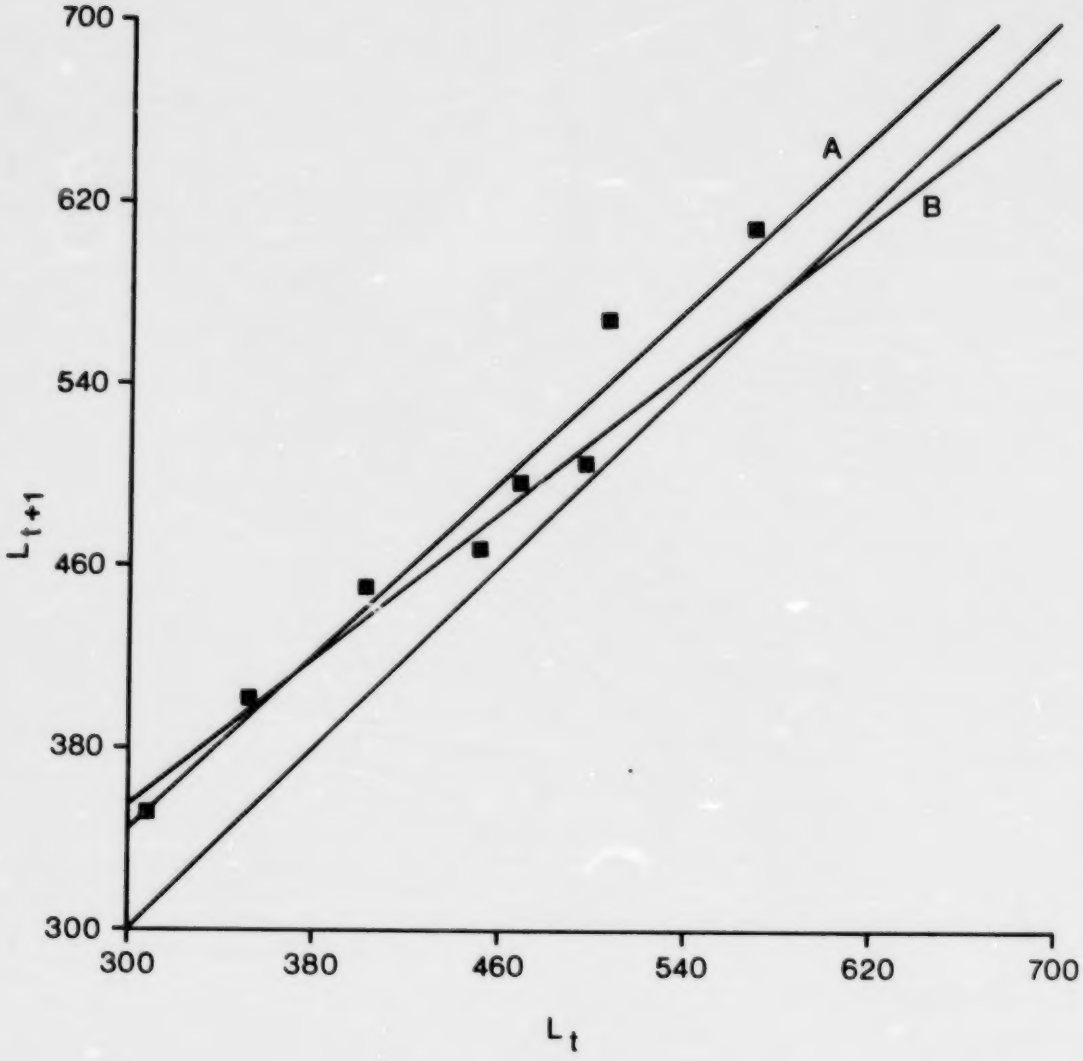

Fig. 9. Walford plot of whitefish lengths. A - using all points. B - deleting last two points.

Table 9. Linear equations of Walford plots fitted by least squares regression.

Species	Linear equation	L_∞ (mm)	Correlation coefficient	Test F value, d.f.
walleye	$L_{t+1} = 100.596 + 0.818L_t$	550	0.922	51.28(1, 9)
	$L_{t+1} = 150.905 + 0.707L_t$ [1]	515	0.885	29.00(1, 8)
whitefish	$L_{t+1} = 114.407 + 0.803L_t$ [2]	578	0.986	141.94(1, 4)

1. L_2 deleted from analysis.

2. L_{10} and L_{13} deleted from analysis.

Table 10. Fitted growth curves of Cedar Lake walleyes and whitefish, 1980.

Species	Curve type	Equation	Correlation coefficient
walleye	untransformed growth	length = 197.879 + 25.064 age	0.922
	exponential growth	$\log_e$ length = 4.884 + 0.541 $\log_e$ age	0.963
	$\log_e (L_\infty - l_t)$ vs. t using L_∞ = 550 and all ages (Fig. 10)	Y = 6.549 - 0.231X	-0.873
	1. $\log_e (L_\infty - l_t)$ vs. t using L_∞ = 550 and deleting ages 11,12 13 and 15 (Fig. 10)	Y = 6.519 - 0.219X	-0.979
	2. $\log_e (L_\infty - l_t)$ vs. t using L_∞ = 515 and deleting ages 3,11 12, 13 and 15 (Fig. 10)	Y = 6.965 - 0.328X	-0.954
	von Bertalanffy growth re: equation (1)	$l_t = 550\ (1 - e^{-0.219(t - 0.954)})$	
	von Bertalanffy growth re: equation (2)	$l_t = 515\ (1 - e^{-0.328(t - 2.198)})$	
whitefish	untransformed	length = 244.968 + 30.117 age	0.978
	exponential growth	$\log_e$ length = 5.231 + 0.469 $\log_e$ age	0.993
	$\log_e (L_\infty - l_t)$ vs. t using L_∞ = 578 and all ages	Y = 7.046 - 0.380X	-0.872
	3. $\log_e (L_\infty - l_t)$ vs. t using L_∞ = 578 and deleting age 10 (Fig. 11)	Y = 6.296 - 0.230X	-0.995
	von Bertalanffy growth re: equation (3)	$l_t = 578\ (1 - e^{-0.230(t - 0.276)})$	

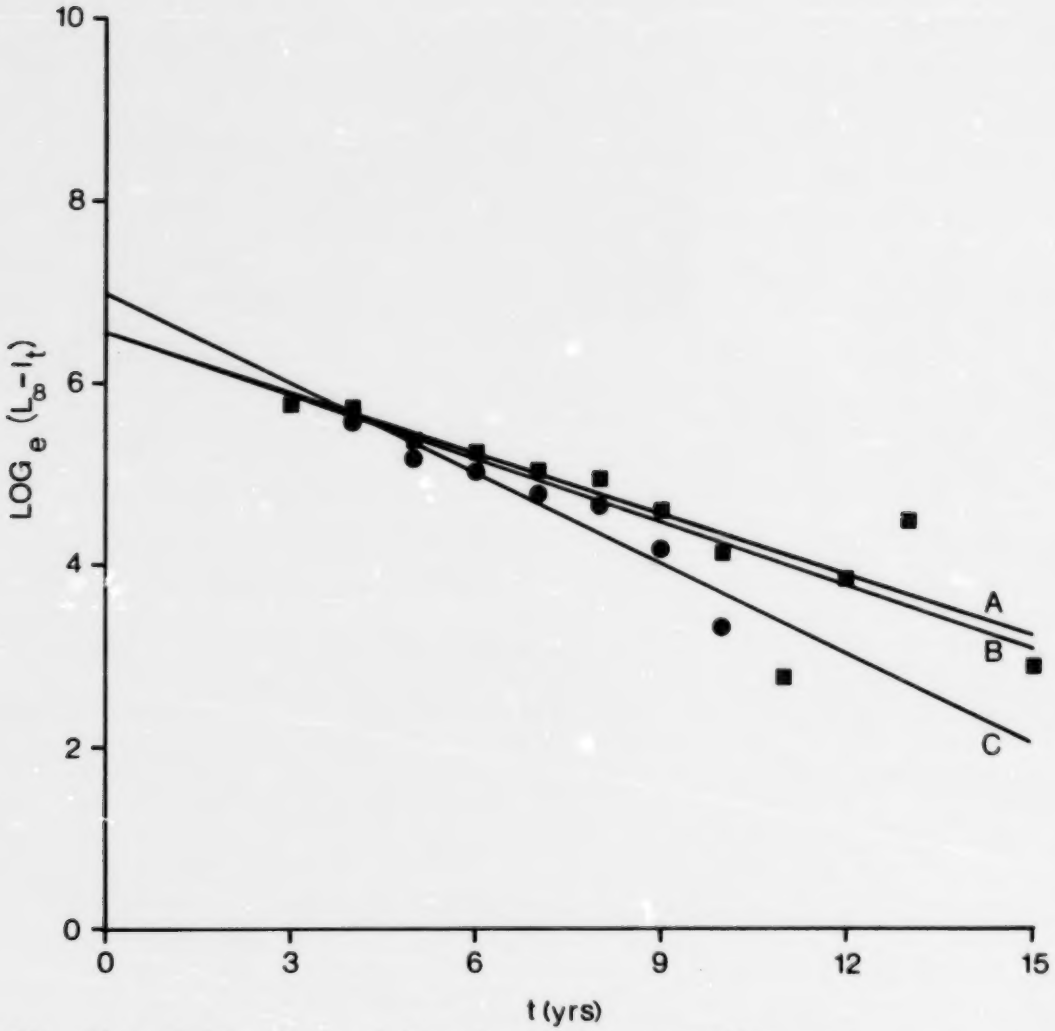

Fig. 10. Plot of $\log_e (L_\infty - l_t)$ versus t of age-specific mean lengths of walleyes. A - L_∞ = 550 mm and last four points deleted from regression (■). B - L_∞ = 550 mm and all points included in regression (■). C - L_∞ = 515 mm and lengths at t = 3, 11, 12, 13 and 15 deleted from regression (●).

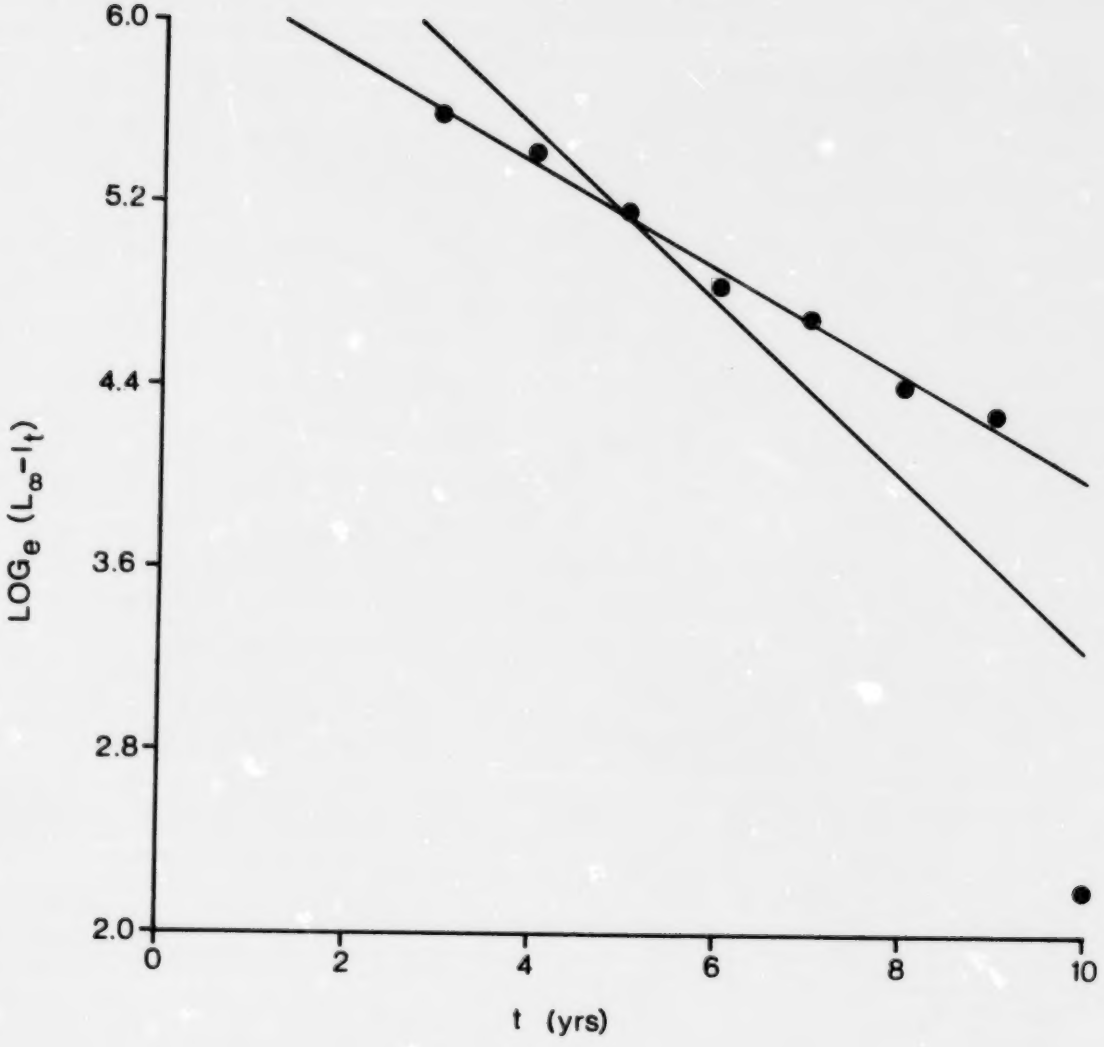

Fig. 11. Plot of $\log_e (L_\infty - l_t)$ versus t for age-specific mean lengths of whitefish. Length at 10 years was deleted from analysis.

Commercial Sampling

Ages of commercially caught whitefish ranged from 3 to 8 years. The commercial whitefish age composition (Fig. 12) was more leptokurtic than the experimental age composition and contained only 2 age classes that each comprised over 20% of the total whitefish catch. The mean weighted age of the commercial whitefish catch was 4.72 years. Regression analysis of the descending limb of the whitefish catch curve (Fig. 13) yielded an instantaneous total mortality rate of 1.023 ($F = 170.85$, 1 and 1 d.f., $P = 0.05$). The corresponding survival rate, 0.3606, was not significantly different from the Robson-Chapman survival rate, 0.3219 (2 S.E. = 0.2236).

Ages of commercially caught walleyes ranged from 6 to 13 years. The commercial walleye age composition (Fig. 14) was less leptokurtic than the experimental walleye age composition and contained 3 age classes that each comprised over 20% of the total walleye catch. The mean weighted age of the commercial walleye catch was 8.26 years. Regression analysis of the descending limb of the walleye catch curve (Fig. 15) yielded an instantaneous total mortality rate of 1.023 ($F = 59.95$, 1 and 1 d.f., $P = 0.05$). The corresponding survival rate, 0.3606, was not significantly different from the Robson-Chapman survival rate, 0.3285 (2 S.E. = 0.2608).

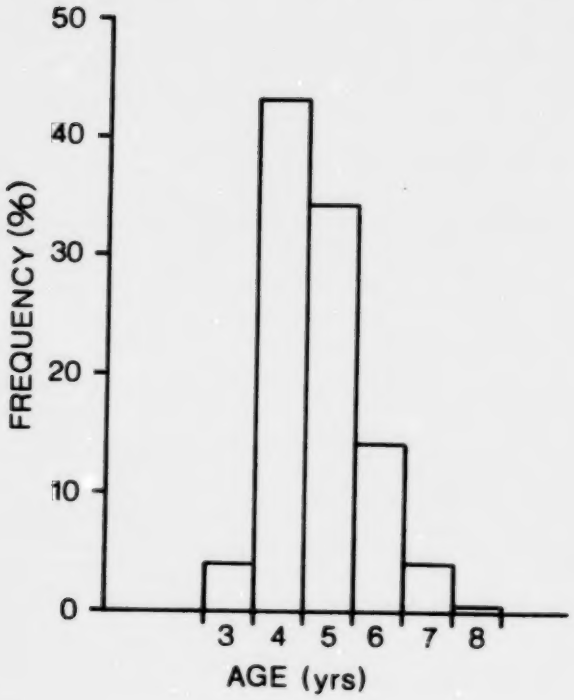

Fig. 12. Commercial whitefish age composition.

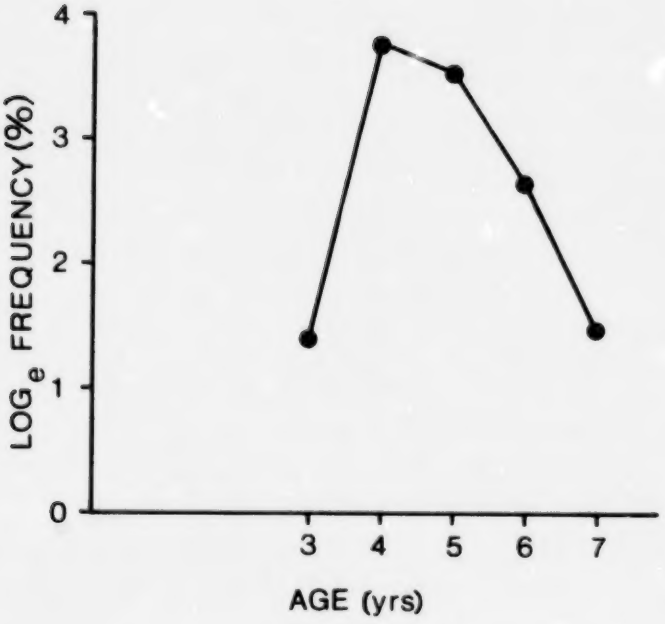

Fig. 13. Commercial whitefish catch curve.

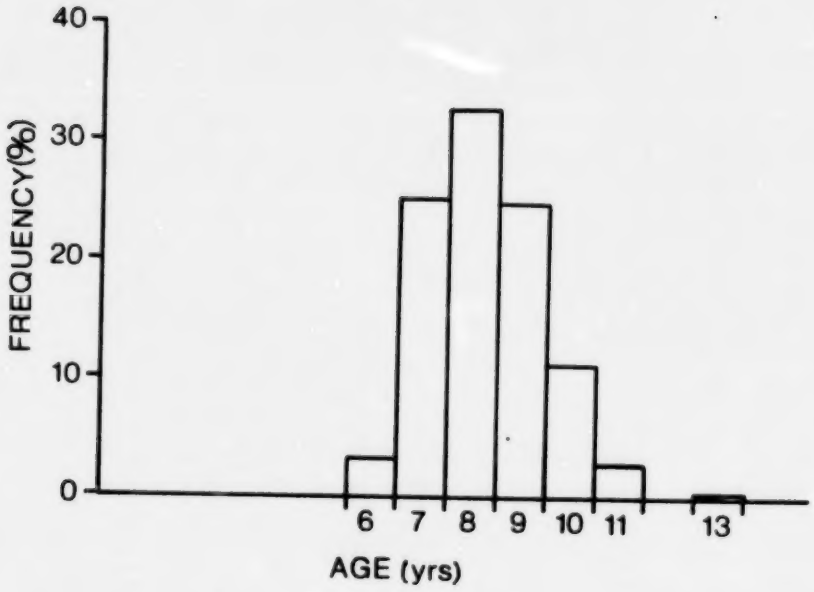

Fig. 14. Commercial walleye age composition.

Fig. 15. Commercial walleye catch curve.

DISCUSSION

Since 1979, the slope of the walleye length-weight curve has increased from 2.934 to 3.028 while the slope of the whitefish length-weight curve has decreased from 3.329 to 3.110. Such yearly changes are probably not significant. Gillnet selectivity affects slopes of length-weight curves. The youngest fish caught in nets usually have high weight to length ratios implying that they lie above the true length-weight curve. The points on the length-weight curves presented in this report are age-specific mean lengths and mean weights. Thus the derived equations describe the "age class length-weight relationships". A line fitted through individual lengths and weights would predict smaller weights at a given length. In spite of this, relative changes in slopes of age-specific length-weight curves over a long term may indicate fishery effects as long as each curve is fitted consistently from year to year.

The estimate of the asymptotic length of whitefish increased from 502 mm in 1979 to 578 mm in 1980. The latter value is more realistic since it approaches the maximum observed length in the 1980 sample. Thus the 1980 whitefish von Bertalanffy growth curve, $l_t = 578 (1 - e^{-0.23 (t + .276)})$, is probably more realistic than the 1979 growth curve, $l_t = 502 (1 - e^{-0.32 (t - 0.202)})$. The linear growth curve of whitefish changed from $l = 266.869 + 25.109$ age in 1979 to $l = 244.968 + 30.117$ age in 1980. The y-intercept decreased and the slope increased because the 1980 sample included younger, smaller fish than were caught in 1979 (Lysack 1980a).

The 1980 estimate of the asymptotic length of walleyes, 515 mm, is relatively close to the maximum observed length. The first point on the Walford plot of walleye lengths was deleted because it represented the fastest growing young fish that were recruited to the experimental gillnets. In such cases where the Walford plot is a poor fit to observed data, the corresponding von Bertalanffy growth curve can depart greatly from reality.

The weighted mean age of experimentally caught whitefish was 5.66 yrs in 1979 and 5.63 yrs in 1980. The 1975 whitefish cohort was strongly recruited to the experimental gang while the 1972 and 1973 cohorts decreased from 17.4% and 31.9% to 8.8% and 10.1%, respectively. The weighted mean age of experimentally caught walleyes increased from 5.84 yrs to 7.34 years since 1979. The 1973 - 1976 walleye cohort strengths all decreased since 1979 but the strengths of the older 1970 - 1972 cohorts increased. Since the 1970 - 1972 cohorts were fully recruited to the commercial nets in 1979, the anomaly was caused by differences between sampling times and/or ageing discrepancies. The 1979 sample was collected in September while the 1980 sample was collected in May. Cohort strength anomalies still occur even if the 1979 age composition is shifted to the right by one year. Six and seven year old walleyes comprised 61% of the 1979 commercial catch. Removal of these younger recruits by the winter fishery may have caused the shift to dominance by older cohorts in 1980.

Robson-Chapman and regression survival estimates of experimentally caught walleyes and whitefish were higher in 1980 than in 1979. Both estimates of commercially caught whitefish were lower in 1980 than in 1979. The regression estimate of commercial walleye survival survival decreased while the Robson-Chapman estimate increased since 1979.

Abrasov's (1967) t index for Cedar Lake walleyes was +1.21 years in 1979 and -0.03 years in 1980. The whitefish t index also decreased from +1.67 years in 1979 to -0.68 years in 1980. These decreases in the t indices may be real or may be artifically induced. Differences in sampling time between 1979 and 1980 and the inclusion of younger fish in the 1980 samples could have caused a decrease in the estimate of mean age of maturity of both species.

The use of fitted maturity curves in determining various parameters of walleye maturation was successful in 1980. Male walleyes begin maturing earlier than females but mature at a slower rate. The maturity rate of Cedar Lake walleyes, irrespective of sex, is very similar to that of northern Lake Winnipeg walleyes (Lysack 1980b). The use of fitted maturity curves in determining maturation parameters of whitefish was unsuccessful because:

1. age-specific frequencies of mature whitefish rose rapidly between the ages of 4 and 5 years, 2. near asymptotic frequencies of mature whitefish occurred for three consecutive age classes. These had to be deleted from the analysis, and 3. very few young whitefish were caught in experimental gangs.

In general, it appears that the status of walleye and whitefish stocks has not changed significantly since 1979. Any minor changes may be attributed to seasonal variation in sampling time. In 1980, the Cedar Lake quota was increased by 100,000 lbs. Future stock assessment programs on Cedar Lake will reveal the effect of this quota increase on the status of fish stocks. It is hypothesized that growth rates and maturity rates will increase to compensate for heavier fishing pressure.

RECOMMENDATIONS

1. The 1981 Cedar Lake stock assessment project should be carried out during late May using the same gillnet set locations and types of gangs as were used in 1980.
2. Estimates of species proportions should be determined in the same manner as used in 1980.
3. If necessary, sampling effort should be extended until more smaller whitefish are caught.
4. To determine the effect of one quota change on the status of fish stocks, further quota changes should not be made in the near future. Yearly changes in quotas probably have an interactive effect on population dynamics. Thus responses in vital parameters cannot be directly related to any one quota change.

ACKNOWLEDGMENTS

Bob Olynyk, Martin Erickson and Rich Janusz collected experimental and commercial data and samples. Ages of walleyes and whitefish were determined by the fish ageing group in the Biological Services section of the Dept. of Natural Resources, Fisheries Branch. This report was edited by K. Campbell and J. O'Connor. B. Bean typed the manuscript. Sincere appreciation is extended to all participants.

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APPENDIX A
SPECIES PROPORTIONS

Table A1. Numbers of each fish species caught in experimental gangs.

Gang no.	Mesh size (in)	Species									
		walleye	whitefish	pike	tullibee	white sucker	longnose sucker	perch	sauger	burbot	goldeye
1	2	0	0	2	1	0	0	0	0	0	0
	3	5	13	30	30	1	0	6	1	0	0
	3.25	5	9	30	31	0	0	1	1	0	0
	3.75	3	16	22	14	1	0	0	1	0	0
	4.25	1	23	8	20	C	1	0	0	0	0
	5	1	39	2	7	0	0	0	0	1	0
	Σ =	15	100	94	103	2	1	7	3	1	0
2	2	0	0	1	4	0	1	2	0	0	0
	3	9	5	71	14	0	0	0	0	0	0
	3.25	13	6	47	17	6	0	4	0	0	0
	3.75	6	5	34	16	9	0	0	0	0	0
	4.25	0	8	11	27	1	0	0	0	0	0
	5	1	25	1	19	5	0	0	0	0	0
	Σ =	29	49	165	97	21	1	6	0	0	0
3	2	0	0	1	5	0	0	0	0	0	0
	3	1	3	18	16	1	0	1	0	2	0
	3.25	1	3	12	7	1	0	2	3	2	0
	3.75	0	6	9	8	1	0	0	1	1	0
	4.25	0	0	2	3	0	1	0	0	3	0
	5	0	2	0	2	0	0	0	0	6	0
	Σ =	2	14	42	41	3	1	3	4	14	0

4	2	0	0	12	2	0	0	0	0	0	0
	3	22	4	108	27	11	2*	2	0	0	1
	3.25	44	2	112	17	13	0	2	0	0	0
	3.75	27	4	44	12	18	0	0	0	0	0
	4.25	2	6	16	5	12	0	0	0	0	0
	5	4	14	3	4	13	0*	0	0	0	0
	Σ =	99	30	295	67	67	2	4	0	0	1

* 1 redhorse sucker

5	2	0	0	0	7	0	0	0	0	0	0
	3	17	9	47	39	1	0	2	1	0	0
	3.25	9	3	36	33	2	1	1	0	0	0
	3.75	10	8	16	18	3	0	0	0	0	0
	4.25	2	6	10	10	1	0	0	0	0	0
	5	1	9	3	4	5	1	0	0	0	0
	Σ =	39	35	112	111	12	2	3	1	0	0
6	2	8	0	2	7	0	0	1	0	0	0
	3	23	3	39	63	2	0	5	0	0	0
	3.25	28	0	27	47	1	0	8	0	0	1
	3.75	14	4	31	32	9	0	0	0	0	0
	4.25	4	2	8	8	3	0	0	0	0	0
	5	3	4	3	8	14	0	0	0	0	0
	Σ =	80	13	110	165	29	0	14	0	0	1
1-6	2	8	0	18	26	0	1	3	0	0	0
	3	77	37	313	189	16	2*	16	2	2	1
	3.25	100	23	264	152	23	1	18	4	2	1
	3.75	60	43	156	100	41	0	0	2	1	0
	4.25	9	45	55	73	17	2	0	0	3	0
	5	10	93	12	44	37	1*	0	0	8	0
	Σ =	264	241	818	584	134	7	37	8	16	2

* 1 redhorse sucker

APPENDIX B
GROWTH CURVES OF IMMATURE AND MATURE MALE AND FEMALE WALLEYES AND WHITEFISH

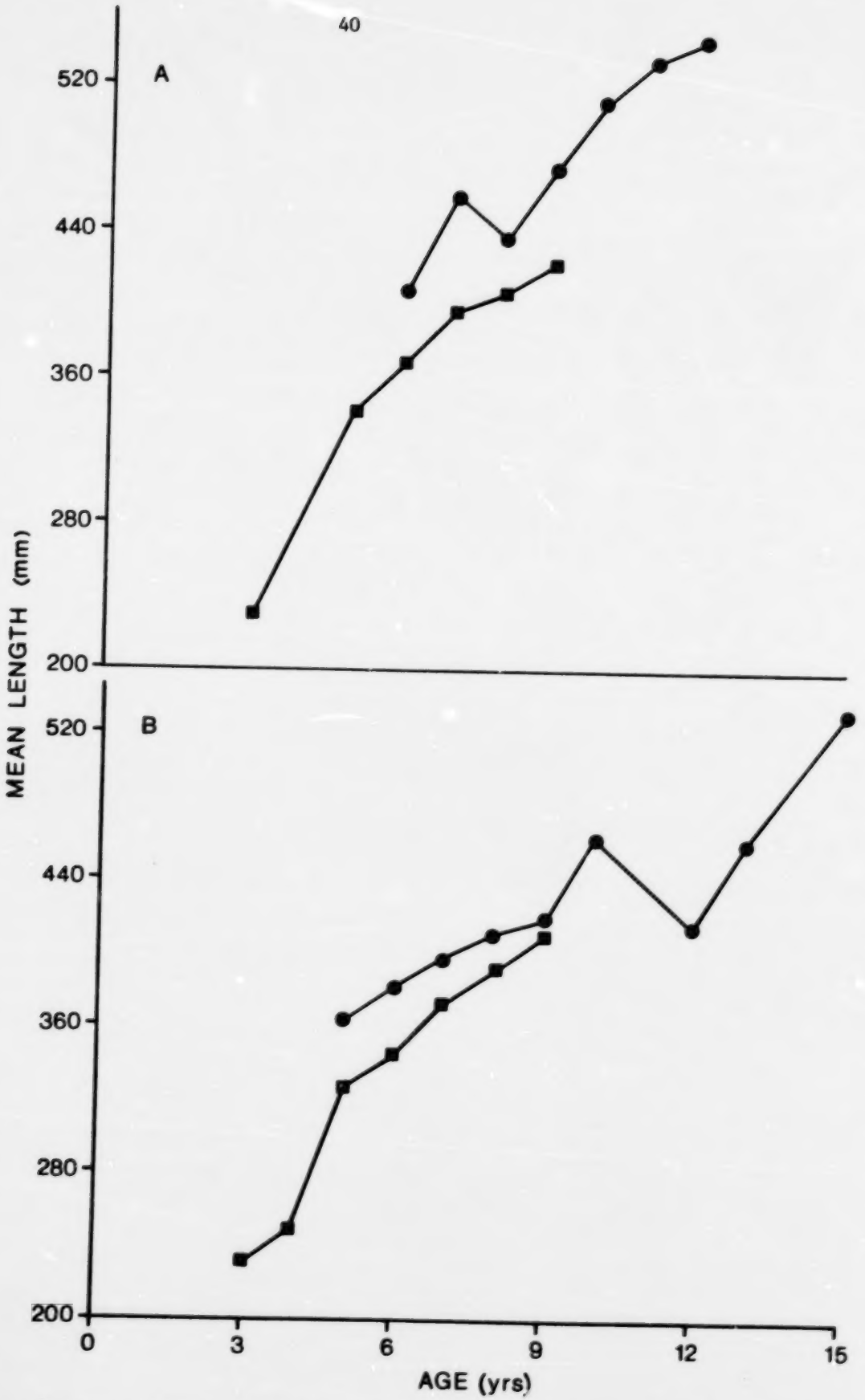

Fig. B1. Growth curves of immature (■) and mature (●) female (A) and male (B) walleyes.

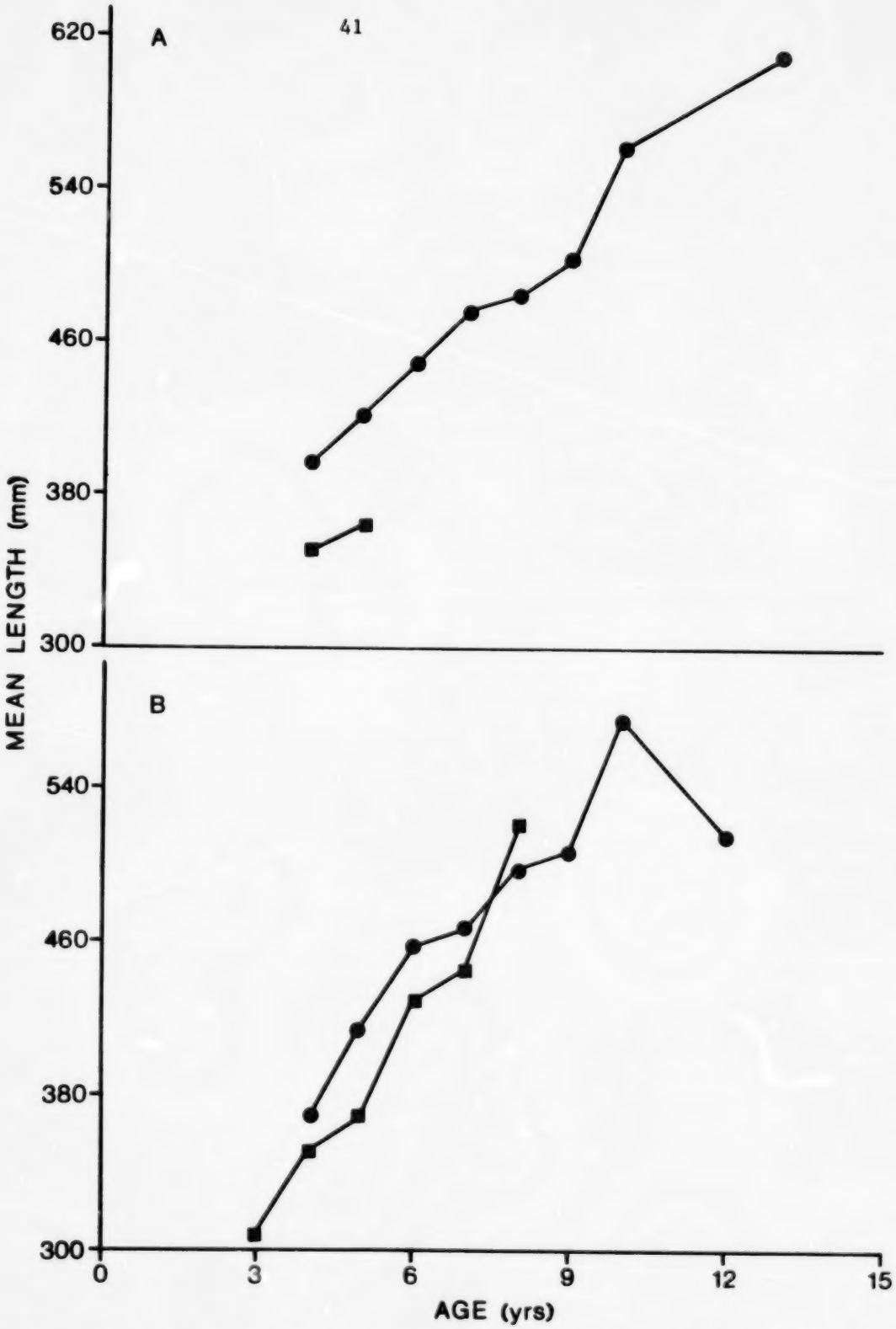

Fig. B2. Growth curves of immature (■) and mature (●) female (A) and male (B) whitefish.